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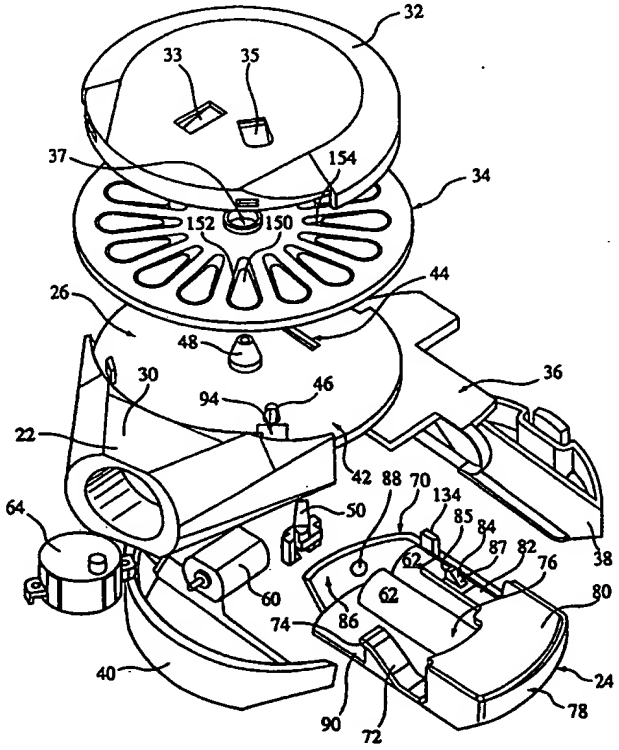
(54) Title: DRY POWDER INHALER

(57) Abstract

A dry powder inhaler (20) with a slider (24) for incrementally advancing a blister disk (34), for providing doses of dry powder medicament, with the blister disk (34) rotatably supported by a spindle (48) on a deck plate (42) of the inhaler (20). The deck plate (42) has a powder port (94), an advance slot (44), and a lifter slot (46) extending through the deck plate (42). The slider (24) attached to the deck plate (42) is movable between an open, and closed position. When the slider (24) opens, the lifter (50) moves up the ramp (72) of the slider (24) shearing open a blister (39), the blister (39) contents mix with air, and are then inhaled by a patient. As the slider (24) moves back to the closed position, the lifter (50) withdraws, and an advancing finger (84) turns the blister disk (34) to the next blister (39), positioning the blister (39) for opening, to provide the next dose to the patient. A turbine (230) spins up to a high speed driven by the flow of the patient's inhalation. The turbine (230) is connected to a shaft (246) to turn a propeller (226) located within a mixing chamber (224).



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DESCRIPTION

DRY POWDER INHALER

Background Of The Invention

The field of the invention is inhalers for delivering dry powder drugs to the lungs. Inhalers have long been used to deliver drugs into a patient's lungs. Typically, an inhaler provides a mixture of drugs and air or propellant gases. The mixture is delivered via the patient inhaling from a mouthpiece on the inhaler, for treatment of various conditions, for example, bronchial asthma. However, delivery of drugs via inhalation can be used for many other treatments, including those unrelated to lung condition.

Metered Dose Inhalers (MDIs) have been widely used for many years. MDI's typically dispense a single dose of a drug together with a propellant gas, with each actuation of the device. However, the propellant gases have been linked to destruction of the earth's ozone layer. In addition, with MDI's, the drug is generally released upon actuation of the device, regardless of whether the patient is properly inhaling during release. The patient may therefore not receive a complete dose unless the patient coordinates inhalation with actuation of the device. Achieving this coordination may be difficult for young children, or for patients with disabilities or under duress. Dry powder inhalers, on the other hand, do not have these disadvantages. Still, with dry powder inhalers, technical challenges remain in providing a reliable and simple to use device which can consistently deliver correct dosages of drugs.

One well known dry powder inhaler, the Diskhaler, described in U.S. Patent No. 4,627,432, uses individual drug doses sealed within blisters on a blister disk. A plunger pierces the blisters, to release each dose. The disk is advanced by a knob with each successive dose. The Spiros inhaler, described in U.S. Patent No. 5,622,166 (incorporated herein by reference) is a dry powder inhaler which also uses a blister disk. Blisters are opened via shear tabs on the blister disk. The disk is advanced to provide the next dose by sliding the mouthpiece cover between open and closed positions. While these types of devices may have met with varying degrees of success, disadvantages remain in indexing or advancing a blister disk within an inhaler, with opening the blisters to access the drug contents, with reliably providing intended dosages, and in other areas.

Accordingly, it is an object of the invention to provide an improved dry powder inhaler.

Statement Of The Invention

To these ends, a drug dose carrier, such as a blister disk, is advantageously rotatably supported on or in a dry powder inhaler for pharmaceuticals. A slider is preferably attached to a housing or deck plate of the inhaler, and is movable between opened and closed positions. The slider may advantageously contain batteries or other electronic components electrically linked to components positioned in the main body of the inhaler via a flex circuit. Movement of the slider between the open and closed positions, in a preferred embodiment, opens a container on the carrier disk to release a pharmaceutical powder for inhalation. Preferably, this movement also advances the carrier, in preparation for delivery of a subsequent dose.

In a second aspect of the invention, a propeller spins within a mixing chamber and is turned by a turbine driven by the patient's inhalation.

Brief Description Of The Drawings

Fig. 1 is a perspective view of the inhaler of the invention with the slider in the closed or first position;

Fig. 2 is a perspective view thereof with the slider in the open or second position;

Figs. 3A and 3B are exploded top and bottom perspective views of the inhaler shown in Figs. 1 and 2;

Figs. 4A and 4B show enlarged perspective views of components of the inhaler of Figs. 3A and 3B;

Fig. 4C is a perspective view of the lifter shown in Fig. 4A;

Fig. 5 is a top perspective view of the deck plate shown in Figs. 3A and 3B;

Fig. 6 is a bottom perspective view thereof;

Fig. 7 is a section view thereof taken along a lateral centerline;

Fig. 8 is a perspective view of the flex circuit shown in Figs. 3A and 3B;

Figs. 9 and 10 are perspective views of the disk and cover shown in Figs. 3A, 3B and 4A;

Fig. 11 is a cross section view thereof taken through the anti-back up pawl shown in Fig. 9;

Fig. 12 is a central cross section thereof;

Fig. 13 is an exploded perspective view of a blister disk;

Fig. 14 is a top view thereof;

Fig. 15 is a section view thereof;

Fig. 16 is an exploded perspective view of another embodiment having a turbine in place of an electric motor;

Fig. 17 is a perspective view of the inhaler shown in FIG. 16;

Fig. 18 is a perspective view thereof, also showing internal turbine details;

Fig. 19 is a schematic view showing air flow through the inhaler; and

Fig. 20 is an enlarged view of details shown in Fig. 19.

Detailed Description Of The Drawings

Turning now in detail to the drawings, the inhaler **20** includes a mouthpiece **22**, and a slider **24**, movable between a closed position, as shown in Fig. 1, and an open position as shown in Fig. 2. A handle **77** may be provided on the slider **24**.

Turning to Figs. 3A, 3B and 5-7, a deck plate **42** has a flat top surface **26** and a flat bottom surface **28**. A spindle **48** extends upwardly from the top surface **26** of the deck plate **42**. A lifter slot **46** passes through the deck plate **42**. An advancing slot **44** extends through the deck plate parallel to the direction of motion of the slider **24**. A blister disk **34** used with the inhaler **20** includes a plurality of drug containing blisters **39** mounted on tabs **50**, as described, for example, in U.S. Patent No. 5,622,166, incorporated herein by reference.

Turning momentarily to Figs. 13, 14 and 15, the blister disk **34** is made of a metal foil ring **200** having generally conical blisters **37** radially and equally spaced apart. The metal foil ring **200** and a seal ring **202** are adhered or bonded onto a carrier disk **204**. The disk **204** is preferably plastic. The carrier disk **204** has tabs **150** pivotably attached to the disk **204** via flex joints **152**. A blister **39** is aligned over each tab **150**. The flex joints **152** hold the tabs **150** into a flat, in-plane position, but allow the tabs **150** to pivot about the

flex joints **152**, with nominal torque. As shown in Fig. 15, powdered drug **205** is contained within each blister **39**.

A cover **32** is attached over the top surface of a blister disk **34** to form a cover/disk assembly or unit **45**. The blister disk **34** has a central opening **37** so that it can be mounted on and rotate around the axis of the spindle **48** which is normal to the axis of motion of the slider. The cover **32** itself latches onto the deck and does not rotate. The cover **32** retains the blister disk onto the deck as the blister disk rotates. Referring specifically to Figs. 3B and 5-7, a back rim **104** extends downwardly from the deck plate **42**, opposite from the mouthpiece **22**. A recess **102** in the deck plate **42** and back rim **104** allows for the motion of a latch **55** to lock the disk/cover assembly **45** onto the inhaler **20** when the cover blister disk assembly **45** is replaced by the user. A slider guide plate **114** extends downwardly from the bottom surface **28** of the deck plate **42**. Slider lever guides **112** similarly are positioned on the bottom surface **28** of the deck plate **42**, parallel to the advancing slot **44**. Lifter guides **108** forming leg slots **110** are also attached to the bottom surface **28** of the deck plate **42** under the lifter slot **46**, as best shown in Fig. 6. The leg slots **110** define the degree of freedom for the lifter motion.

A powder port **94** extends downwardly through the deck plate **42** and into an air passage **92** formed on the underside of the deck plate **42**, heading to an aerosolizing or mixing chamber **106**. The mouthpiece is advantageously removably attached to the deck plate **42**. The spindle **48**, back rim **104**, slide guide plate **114**, lever guides **112**, and lifter guides **108** are preferably integral with the deck plate.

Referring back to Figs. 3A, 3B, 4A and 4B, the slider **24** includes a slider frame **70** attached to a bottom plate **90**, forming a battery compartment **76**. A lifter ramp **72** is attached or formed along one side of the slider bottom plate **90**. A lifter **50**, as shown in Figs. 4A, is slidably attached to the ramp **72**. The lifter **50** includes L-legs **52** for holding the lifter **50** onto lips **74** on the ramp **72** and for retracting the lifter **50** from its raised position. The lifter **50** has a flat top surface **51** and an angled surface **54**. The lifter ramp **72** passes under the lifter **50** as the slider **24** moves in and out. The lifter ramp **72** defines the cam profile which induces vertical motion in the lifter **50** as a result of the horizontal motion of the slider **24**.

Referring to Figs. 3A, 4A and 4B, a slider cover plate **80** is attached to the slider frame **70**, at the front or outside end **78** of the slider. A leg **82** on the slider cover plate **80**

extends inwardly toward the rear end **86** of the slider **24**. A spring biased or resilient advancing finger **84** having a flat back surface **85** and an angled front surface **87** projects upwardly from the leg **82**. A battery check button extends through an opening **88** in the rear end **86** or bottom side **90** of the slider. As shown in Figs. 3A and 3B, a rear housing section **38** and a front housing section **40** are attached to the bottom surface of the deck plate **42**, on either side of the slider **24**, to enclose the inhaler and capture the slider in its guides, allowing only one degree of freedom. The front end **78** and rear end **86** of the slider are preferably shaped to match the contours of the inhaler.

A mechanical stop **134** on the slider engages a ledge **136** on the deck plate, to limit the outward sliding movement of the slider. Finger ridges or gripping features **75** may be provided on the bottom of the slider, as shown in Fig. 3B.

Referring to Figs. 3A, 3B and 8, a flex circuit **36** includes a battery plate **120** having battery slots **122**. A circuitry area **126** is electrically connected to the battery plate **120** by a flexible ribbon **128**. A switch **124** projects from the battery plate **120**. An LED plate **130** and a motor lead tab **132** are provided as part of the circuitry area **126**. A microprocessor **160** and memory chip **162** are provided on the circuitry area.

Turning to Figs. 9-12, a blister crushing rib **170** projects downwardly from the underside of the cover **32**. The crushing rib **170** is positioned so that when the cover/blister disk assembly **45** is assembled onto the inhaler **20**, the rib **170** aligns just behind the powder port **94**. A tab return spring **35** extends downwardly inside the cover **32**. The tab return spring **35** pushes downwardly on the inner end of the tab on the blister disk **34**, which is aligned over the lifter **50** and lifter slot **46**. An anti-backup pawl **33** also extends down inside the cover **32**. The pawl **33** has a foot **175** with a flat front surface **177** and an angled or ramp rear surface **179**.

Disk clips **176** having angled bottom facing surfaces are spaced apart around the inside of the cover **32**, on a cylindrical rim wall **186**. A front latch **180** and a rear latch **182** are provided for attaching the cover **32** to the inhaler **20**. Various latch designs may be used. Turning momentarily to Fig. 3A, the front latch fits into or engages a raised area **30** between the mouthpiece **22** and the disk assembly **45**.

Referring to Figs. 10 and 12, a central hub **188** extends down from the center inside surface of the cover **32**. A blister disk **34** and a cover **32** are attached together to form an assembly **45** by aligning the central opening **37** or disk hub **190** of the disk with

the hub **188** on the cover, and then pressing the disk into the cover. As this occurs, the clips **176** spring slightly apart, due to the natural resiliency of the cover material, and then snap back into place, thereby holding the disk and cover together. Once they are snapped together, they are substantially permanently yet rotatably attached to each other. As shown in Fig. 12, the disk **34** may have a perimeter recess **208**, such that the disk clips **176** clip onto a perimeter lip **210** around the outside of the disk.

As shown in Fig. 12, the disk hub **190** and cover hub **188** generally align but do not necessarily engage each other. The disk **34** floats somewhat in the cover. When installed, the disk centers itself on the spindle **48**.

Referring once again to Figs. 3A and 3B, an electric motor **60** is connected to batteries **62** in the slider **24** via the battery plate **120**, ribbon **128** and circuitry area **126** and motor lead tabs **132**, which have electrical conductors within them. A breath actuated switch or sensor **64** also attached to the deck plate **42** and flex circuit senses pressure at the mouthpiece **22**, and in response to sensed inhalation signals a microprocessor **160**, which switches on the motor **60**. The motor **60** spins an impeller within the mixing chamber **106**, as described in U.S. Patent No. 5,577,497, incorporated herein by reference.

A label **100**, shown in phantom line in Fig. 2, may be attached to the top of the cover **32**, to identify its contents, and to close off the openings where the pawl **33** and return spring **35** attach to the cover.

In use, the blister disk **34** is provided as an assembly **45** with the cover **32** attached. The cover **32** captures the blister disk **34** and secures them together. Hence, the cover **32** and blister disk **34** are handled as a unit or assembly by the patient. The cover protects the top and sides of the blister disk **34** from damage during handling. The patient attaches the cover/disk assembly **45** to the inhaler **20** via a bayonet, latch, rocker, or other attachment feature, such as the latches **180, 182**. The cover **32** allows the blister disk **34** to rotate on the spindle **48** while the cover itself is irrotatably snapped onto the deck plate. The cover is oriented so that the tab return spring **35** is located over the lifter slot.

With the cover/blister disk unit **45** secured to the inhaler **20** on top of the deck plate **42**, the inhaler **20** is ready for use. The patient pulls the slider **24** from the first or closed position shown in Fig. 1 to the second or open position shown in Fig. 2. Sliding movement of the slider is guided by the lever guides **112** and slider guide **114** and the covers **40** and **38**. Finger grips **76** or a handle **77** may be provided on the slider **24** to

better facilitate pulling the slider out. The slider **24** moves out until the mechanical stop **134** on the slider frame **70** contacts the stop or ledge **136** on the deck plate **42**.

As the slider **24** is withdrawn, the lifter **50**, which is held in position by the lifter guides **108**, rides up on the lifter ramp **72**. This ramp lifting movement causes the angled top surface **54** of the lifter **50** to rise up and protrude through the lifter slot **46** in the deck plate **42**. The flat top surface **51** of the lifter **50** pushes against the underside of a tab **150** on the blister disk **34**, causing a blister positioned over the tab to shear open, as the tab pivots about flex joints **152** which attach the tab to the disk **34**. As the tab pivots, the angled surface **54** of the lifter engages the tab and continues to pivot it about the joints **132**. As the blister shears open, the powdered pharmaceutical **205** contained within the blister falls into the powder port **94** and air passage **92**, as described in U.S. Patent No. 5,622,166.

As the slider **24** is pulled out to the open position, the advancing finger **84** also moves down under the deck plate **42**, as it recedes out of the advance slot **44**.

The lifter **50** is restrained against lateral or longitudinal movement, by the engagement of the L-legs around the lips **74** on the lifter ramp **72** and by the lifter guides **108**. Accordingly, the lifter **50** can move only vertically up or down.

The patient then inhales on the mouthpiece **22**. The inhalation is sensed by the pressure switch **64** which turns on the motor **60**. The motor spins the impeller within the mixing chamber **106** creating an aerosol of air and powdered drug, as described in U.S. Patent No. 5,577,497. The inhalation draws substantially all of the drug from the powder port **94** and staging chamber **92** into the mixing chamber **106**, for inhalation. When inhalation is complete, the pressure switch **64** shuts off the motor **60**. Inhalation preferably occurs when the slider is in the "out" position, when the blister is open and the inhaled air flow can draw any remaining drug out of the blister.

The patient next moves the slider **24** from the open position shown in Fig. 2 back to the closed position shown in Fig. 1. This movement is achieved by pushing on the slider front end **78**. As the slider moves back into the closed position, the lifter **50** is pulled down on the ramp **72**. The top surface **51** of the lifter **50** retracts to a position flush or below flush with the top surface of the deck plate **42**. The cam profile of the lifter ramp **72** is designed to allow the lifter **50** to return to its neutral (down) position before the blister disk is incrementally advanced. The tab return spring **35** exerts a downward force

on the tab, to push the tab back into a horizontal orientation. The tab return spring also helps to keep the disk flat against the deck, by exerting a downward spring force on the disk. The cover hub **188** also exerts a downward force on the disk as well.

At the same time, the advancing finger **84** moves into the advance slot **44** and flexes or springs upwardly. The flat back surface **85** of the advancing finger protrudes upwardly through the advance slot **44** and extends into a tab slot **154** on the blister disk **34**. Continued closing movement of the slider **24** drives the advancing finger to rotate the disk **34**. The blister crushing rib **170** crushes down the conical point of the blister. This provides a visual indication through the transparent cover that the dose in that blister has been used and allows the patient to easily visually check the number of remaining doses on the disk. With the slider **24** completely moved back to the closed position, the advancing finger **84** turns the disk **34** through an angle which brings the next subsequent blister tab **150** into alignment with the lifer slot **46** and powder port **94**.

As the disk advances by one position, the foot **175** of the anti-backup pawl **174** rides up and out of the slot **154** and then drops back down into the next slot. The flat front surface **177** of the foot prevents reverse (clockwise when view from above) movement, while the ramp **179** on the back surface allows the foot and pawl to temporarily deflect up to allow the disk to advance in the forward direction.

The flex circuit **36** provides electrical connections between the batteries **62**, motor **60**, switch **64**, and other components, such as lamp indicators, microprocessor, memory chips, etc. The ribbon **128** on the flex circuit **36** allows the batteries and slider to remain electrically connected to the other fixed components, as the slider **24** is moved between open and closed positions. This motion can also be accomplished with flexible wires or cables.

The microprocessor controls the motor via the breath sensor; counts doses delivered; signals low battery voltage; checks battery voltage, and controls LEDS which indicate use conditions of the inhaler.

The in and out movement of the slider is simple and easily achieved by almost all patients. It also provides for a reliable and compact design. Inadvertent actuation is also largely eliminated.

Turning now to Fig. 16, a turbine driven inhaler **210** has a mouthpiece **214** attached to a body **212**. A mouth piece cover **216** is attached to the mouth piece **214** via a

hinge **215**. The mouth piece cover **216** can be pivoted open or removed during inhalation, or for cleaning.

A blister disk **218** having a transparent cover **220** is mounted over a disk plate **222** attached to the body **212**. An aerosolizing chamber **224** is formed in the front wall of the body **212**. These features may be similar to those shown in Fig. 4C.

A turbine **230** supported on the underside of the disk plate **222** has a turbine shaft **246** extending forwardly into the aerosolizing chamber **224**. A propeller **226** is mounted on the forward end of the turbine shaft **246** in the aerosolizing chamber **224**. A lower housing **232** encloses the bottom section of the disk plate **222**. A plunger **234** extends through the lower housing **232**, for opening blisters on the blister disk **218**. The body **212** and lower housing **232** form an inhaler housing **211**.

The design details and operation of the inhaler **210** are similar to the inhalers described in U.S. Patent Nos. 5,622,166. However, the inhaler **210** has no motor, batteries, switch or circuitry. Rather, the spinning propeller **226** is powered purely by the turbine **230**.

Referring to Fig. 17-20, the turbine **230** has a cylindrical turbine housing **240**. A stator 52 is joined to the turbine housing **240** near the turbine inlet **242**. A turbine outlet **244** is preferably positioned on one side of the cylindrical turbine housing **240**, at the outlet end 45 of the turbine **230**. The turbine shaft **246** is rotatably supported within the turbine housing **240** via a bushing **248** near the outlet end **245**, and via a needle bearing **250** near the inlet end **242**. A rotor **254** having pitched turbine blades **256** is attached and centered on the turbine shaft **246** adjacent to the stator **252**.

Turning to Figs. 19 and 20, and air inlet path **236** extends from the outside environment into the inhaler **210**, and to the inlet end **244** of the turbine **230**. A turbine outlet duct or path **260** runs from the turbine outlet 44 to a dump chamber **262** in the body **212** of the inhaler **210**. An aerosolizing chamber duct **264** extends from the dump chamber **262** to the aerosolizing chamber **224**. A chamber wall **215** in the mouth piece **214**, as shown in Fig. 16 forms the front wall of the aerosolizing chamber **224**, when the mouth piece **214** is attached on to the body **212**. Openings in the chamber wall **215** allow the drug/air mixture to flow from the aerosolizing chamber **224** through the mouth piece **214** to the patient.

In use, a dose of dry powered drug is delivered into the dump chamber **262** from the blister disk **218**, as described in U.S. Patent Nos. 5,622,166. The patient places the lips over the mouth piece **214** and inhales. Upon inhalation, ambient air flows through the inlet air path **236** to the inlet end **242** of the turbine **230**. The air flowing at right angles to the plane of the rotor **254** rapidly spins up the rotor and turbine shaft **246**, simultaneously rapidly spinning up the propeller **226** which is directly mounted on to the front end of the turbine shaft **246**. The rotor blades are pitched so that the air flow through the turbine, parallel to the axis of the turbine shaft, exerts torque, causing the rotor to spin. Air flows out of the turbine outlet 244 to the dump chamber **242**. Dry powder pharmaceutical particles are entrained in the air flow and carried through the aerosolizing chamber duct **264** into the aerosolizing chamber **224**. The particles are de-agglomerated and mixed with air in the aerosolizing chamber **224**. The air and particles pass out of the aerosolizing chamber **224** through openings in the chamber walls **215** and into the patient's mouth, throat, and lungs.

Preferably, the turbine is designed to that the turbine shaft will spin at from 5,000-15,000 rpm with an inspiration flow rate of 20-40 liters per minute. Most preferably, the turbine 30 is designed so that it spins up to 10,000 rpm or greater, within 100 milliseconds, with an inspiration flow rate of about 30 liters per minute. The stator **252** may have fixed vanes to better direct air flow to the rotor **254**. Additional rotors **254** may optionally be added to the shaft **246**.

The air flow through the inhaler **210** is substantially sealed, so that all air inhaled by the patient passes through the inlet air path **236**, the turbine **230**, the turbine outlet duct **260**, the aerosolizing chamber duct **264**, the aerosolizing chamber **224**, and out through the mouth piece **214**. For embodiments not having a separate dump chamber, air flowing out of the turbine may go directly into the aerosolizing chamber. Alternatively, a fraction of the total airflow into the patients lungs may be either inletted or channeled through ducts in the mouthpiece or inhaler to help beneficially entrain, mix, or guide the particle laden air mixture.

The turbine **230** may advantageously be provided as a separate subassembly installed into the inhaler **210** during manufacture. As a result, various other components of the inhaler, not requiring the precision tolerances necessary in the turbine, can be

manufactured and assembled separately. The turbine is compact, preferably having a housing diameter of 1-2 centimeters.

As shown in FIGs. 19 and 20, the dry powder does not flow through the turbine **230**. Rather, the turbine **230** is upstream from the powder. The turbine therefore avoids clogging, friction, or bearing failure from powder particles, as the turbine is upstream of the powder. Although the turbine **230** uses the same air flow which entrains the powder, no balancing of air flow paths is required, and no coordination or timing of the spin-up of the turbine is needed, as the turbine automatically spins up upon inhalation.

The inhaler **210** consequently provides advantages of a motorized inhaler, without the need for a motor or batteries. If electronics are desired to provide an interface with the patient (for example, for dose counting, etc.) then very small batteries may be included to provide the typical low power requirements for such circuitry.

It may be desirable to allow the turbine enough time to reach a minimum acceptable rotary speed to de-agglomerate the drug, before the drug has passed through and out of the aerosolization chamber. One technique for this is to delay the introduction of the pharmaceutical mixture into the aerosolization chamber by sizing the length and diameter of the air path leading to the dump chamber. This allows the turbine time to reach the desired minimum rotational speed. As one example, if the outlet duct **260** is 1cm diameter and 2.5 cm long, during the initial period of inhalation, at a flow rate of 5 liters per minute, the air takes 24 ms to reach the aerosolizing chamber. During that interval the turbine has accelerated up to a sufficient minimum speed.

Alternatively the inhaler may be inverted so that the air flowing through the turbine and hence 'over' the open well containing the blister has to reach a high enough velocity (i.e., **223** liters per minute, depending on how the local geometry is configured) to lift the particles out of the blister well due to Bernoulli's principal, rather than the particles just falling out of the well due to gravity even before the inhalation has begun. This could act as a passive method for regulating when the drug is introduced to the system based on the airflow rate.

In another embodiment intended to have the drug particles exposed to the spinning propeller in the aerosolization chamber is to place the restrictor holes, or outlet holes, near the center of the chamber rather than at the periphery. This would act like a centrifugal size filter, i.e. the larger particles would be forced to the periphery where the most

aggressive de-agglomeration takes place until they are small enough to reach the more centralized outlet holes.

The turbine 230 may replace the motor in the inhalers shown in Figs.1-7 or in the above referenced U.S. Patents.

Claims

1. An inhaler for pharmaceuticals, comprising:

a housing;

a slider slidably attached to the housing;

a ramp and an advancing finger attached to the slider; and

a lifter slidably attached to the housing and to the ramp.

2. The inhaler of claim 1 further comprising a battery compartment in the slider.

3. The inhaler of claim 2 further comprising a flex circuit connecting the battery compartment in the slider to the housing.

4. The inhaler of claim 3 wherein the flex circuit includes a battery plate in the battery compartment of the slider, a ribbon joined to the battery plate, and a circuitry area in the housing joined to the ribbon, and with electrical conductors extending through the battery plate, ribbon, and circuitry area, thereby providing continuous electrical contact between the circuitry area and the battery plate with the slider in the first and second positions.

5. The inhaler of claim 1 further comprising a mouthpiece attached to the housing.

6. The inhaler of claim 1 wherein the slider is slidable from a first position substantially within the housing to a second position extending substantially outside of the housing, with movement from the first position to the second position driving the lifter to engage the carrier disk, and wherein movement of the slider from the second position to

the first position causes the advancing finger to advance through the advancing slot in the deck plate, driving the disk to rotate the disk through an angular motion to a next position.

7. The inhaler of claim 1 further comprising a carrier disk rotatably supported on the housing, the carrier disk having a plurality of equally spaced apart openings and with a tab carrying a blister pivotally attached to the carrier disk within the openings.

8. The inhaler of claim 1 further comprising a deck plate in the housing, the deck plate including an advance slot and a lifter slot, with the advancing finger passing through the advance slot when the slider is in the first position, and with the lifter passing through the lifter slot, when the slider is in the second position.

9. The inhaler of claim 7 wherein the deck plate has a top surface and a bottom surface, a spindle extending upwardly from the top surface for mounting a carrier disk, and a slider guide extending downwardly from the bottom surface, for guiding the slider.

10. The inhaler of claim 8 further comprising an lifter guide on the bottom surface of the deck plate, the lifter guide restraining the lifter in position, except along its path of motion.

11. The inhaler of claim 8 further comprising a mixing chamber in the housing, a motor in the housing and an impeller on the motor, with the motor electrically connected to the flex circuit.

12. The inhaler of claim 8 further comprising a first mechanical stop and a second mechanical stop on the housing for limiting travel of the slider into and out of the housing.

13. An inhaler for pharmaceuticals, comprising:

a deck plate having a first side and a second side;

a spindle on the first side of the deck plate;

a powder port, an advancing slot, and a lifter slot, adjacent to the powder port, each extending through the deck plate;

a blister disk rotatably supported on the spindle, with the blister disk having a plurality of equally spaced apart openings;

a slider attached to the deck plate and movable between a first position and a second position;

a ramp on the slider;

a lifter slidably mounted on a frame on the second side of the deck plate and on the ramp on the slider, the frame allowing the lifter to move only along a specific path of motion towards and away from the lifter opening; and

an advancing arm on the slider biased upwardly against the second side of the deck plate and aligned with the advancing opening.

14. The inhaler of claim 12 wherein the advancing arm converts linear motion of the slider to rotational motion of the blister disk.

15. A cover/disk unit for storing a dry powder pharmaceutcal, comprising:

a blister disk having a metal foil ring and a seal ring bonded on a carrier disk;

a plurality of generally conical blisters formed on a first side of the blister disk, with each blister containing a dose of a dry powder pharmaceutical sealed within the foil ring and the seal ring;

a cover on the blister disk and covering the first side of the blister dis; and means for holding the cover onto the disk while allowing the disk to rotate.

16. The cover/disk unit of claim 14 wherein the means for holding comprises at lest one clip on the cover.

17. The cover/disk unit of claim 14 wherein the means for holding comprises a hub on the cover extending into an opening in the disk.

18. The cover/disk unit of claim 14 further comprising a cylindrical rim wall on the cover extending over the side edges of the disk.

19. A cover/blister disk unit for use with a dry powder inhaler, comprising:

a disk having a plurality of blisters holding a dry powder pharmaceutical; and a rigid cover privotably and permanently attached to one side of the disk over the blisters.

20. The inhaler of claim 1 further comprising a carrier disk rotabtably supported on the housing, the carrier disk having a plurality of equally spaced apart openings and with a tab carrying a blister pivotally attached to the carrier disk within the openings.

21. The inhaler of claim 5 further comprising a cover attached to the carrier disk.

22. An inhaler comprising:

a housing;

an aerosolizing chamber within the housing;

a propeller within the aerosolizing chamber;

a turbine adjacent to the aerosolizing chamber, the turbine having an inlet side and an outlet side;

a turbine shaft extending out of the turbine and into the aerosolizing chamber, with the propeller mounted on the turbine shaft;

a first air pathway extending from an air inlet in the housing to an inlet side of the turbine; and

a second air pathway extending from the outlet side of the turbine to the aerosolizing chamber.

23. The inhaler of claim 22 further comprising a stator on the turbine and a rotor on the turbine shaft.

24. The inhaler of claim 22 wherein the turbine outlet is oriented at an angle to the turbine inlet.

25. The inhaler of claim 22 wherein the turbine is configured to spin the turbine shaft at from 5000 to15000 rpm with a flow rate of 20-40 liters/minute of air flowing through the turbine.

26. The inhaler of claim 22 further comprising a dump chamber in the second air pathway, between the turbine outlet and the aerosolizing chamber.

27. A method of providing a dose of an inhaled pharmaceutical to a patient, comprising the steps of:

providing a pharmaceutical powder into an aerosolizing chamber in an inhaler;

drawing air through a turbine as the patient inhales, thereby spinning a propeller, attached to the turbine, in the aerosolizing chamber;

mixing air and the pharmaceutical powder in the aerosolizing chamber via the spinning propeller.

28. The method of claim 27 wherein the air is drawn through the turbine in a direction perpendicular the plane of a rotor in the turbine.

29. The method of claim 27 further comprising the step of drawing air out of the turbine and through a dump chamber holding a dose of a pharmaceutical .

30. The method of claim 27 wherein the pharmaceutical powder is mixed with air flowing out of the turbine, to avoid having the powder contact the turbine.

31. The inhaler of claim 22 further comprising a rotor attached to the turbine shaft, with the turbine shaft and rotor having an axis of rotation parallel to the direction of air flow through the turbine.

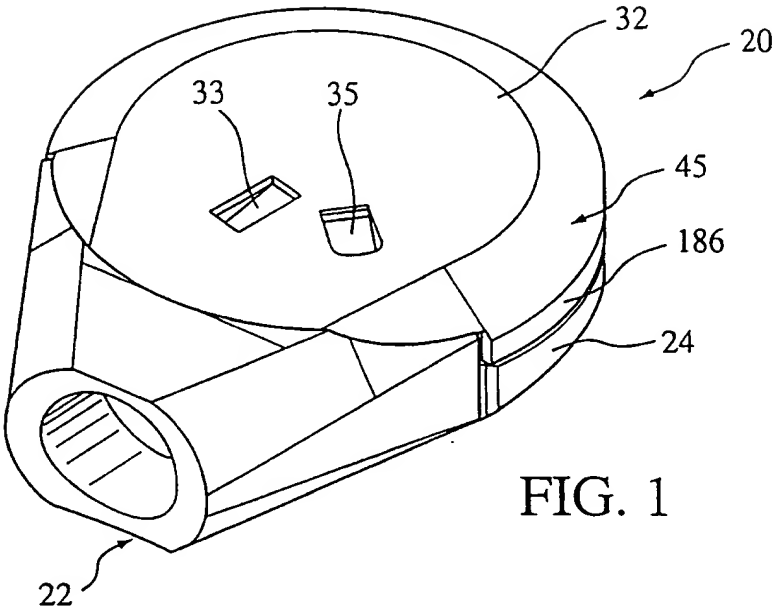

FIG. 1

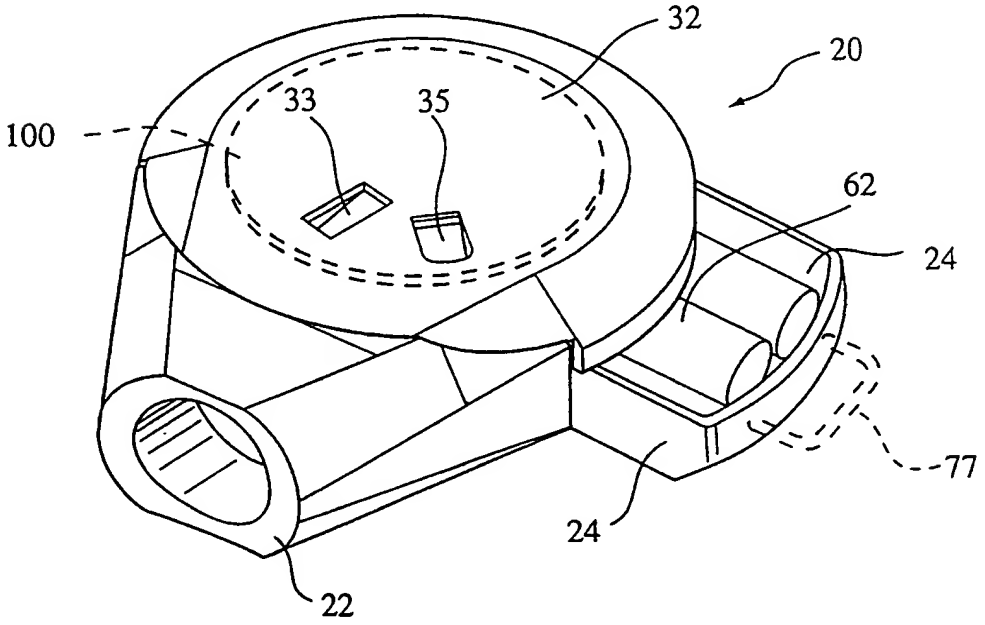

FIG. 2

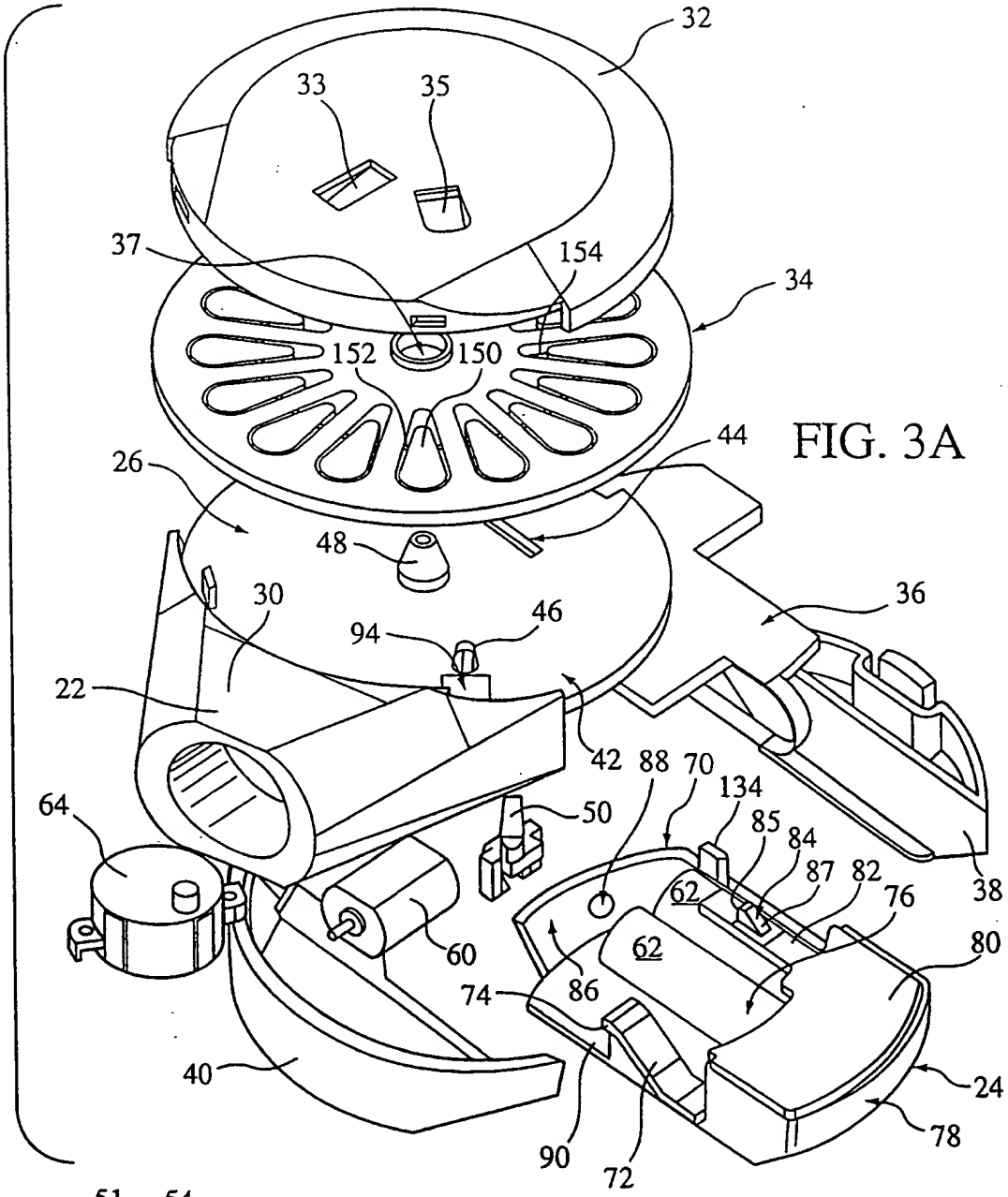
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FIG. 3A

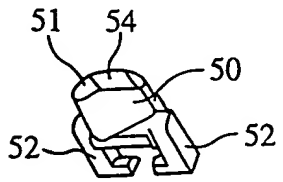
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FIG. 4C

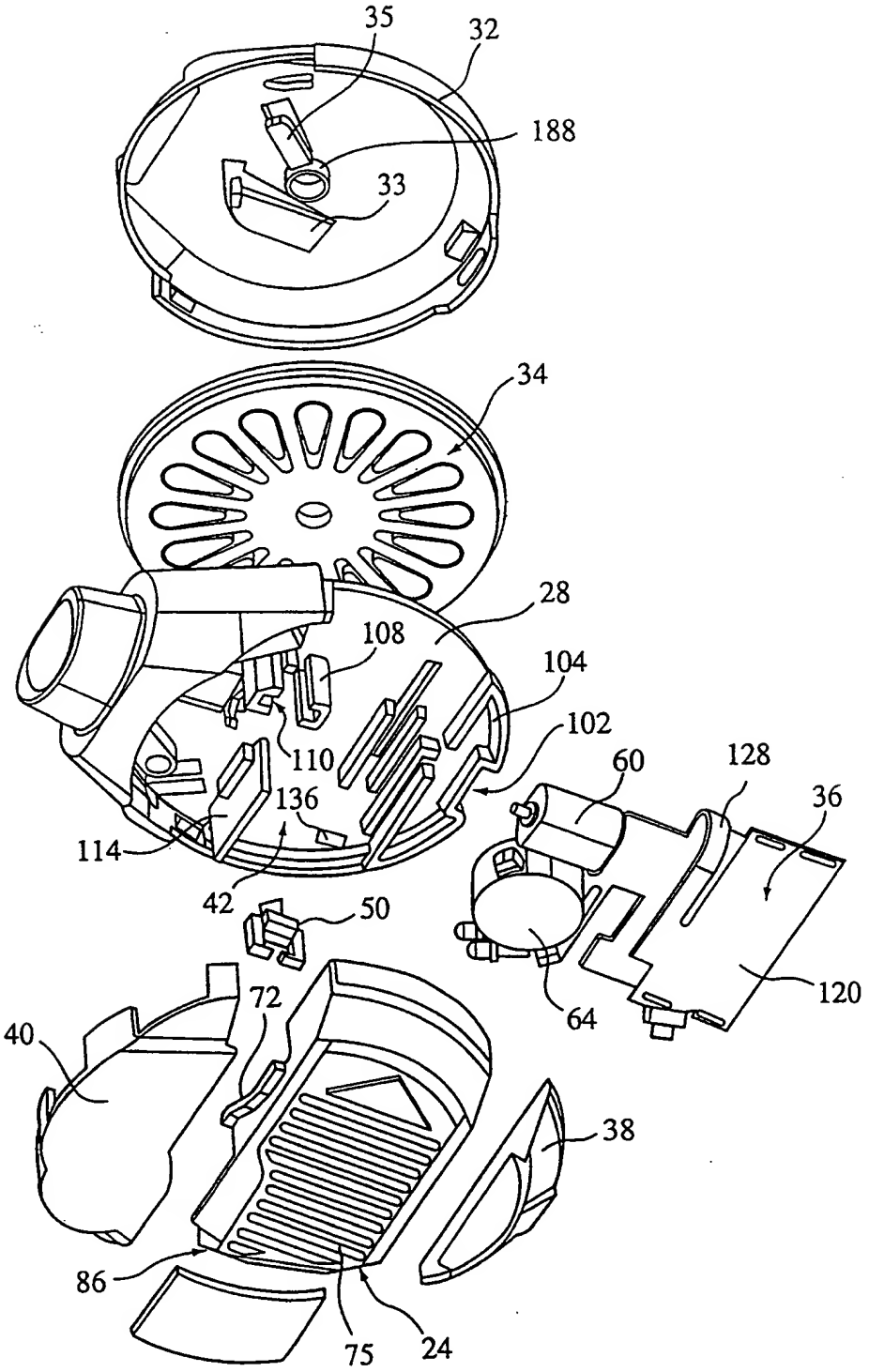
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FIG. 3B

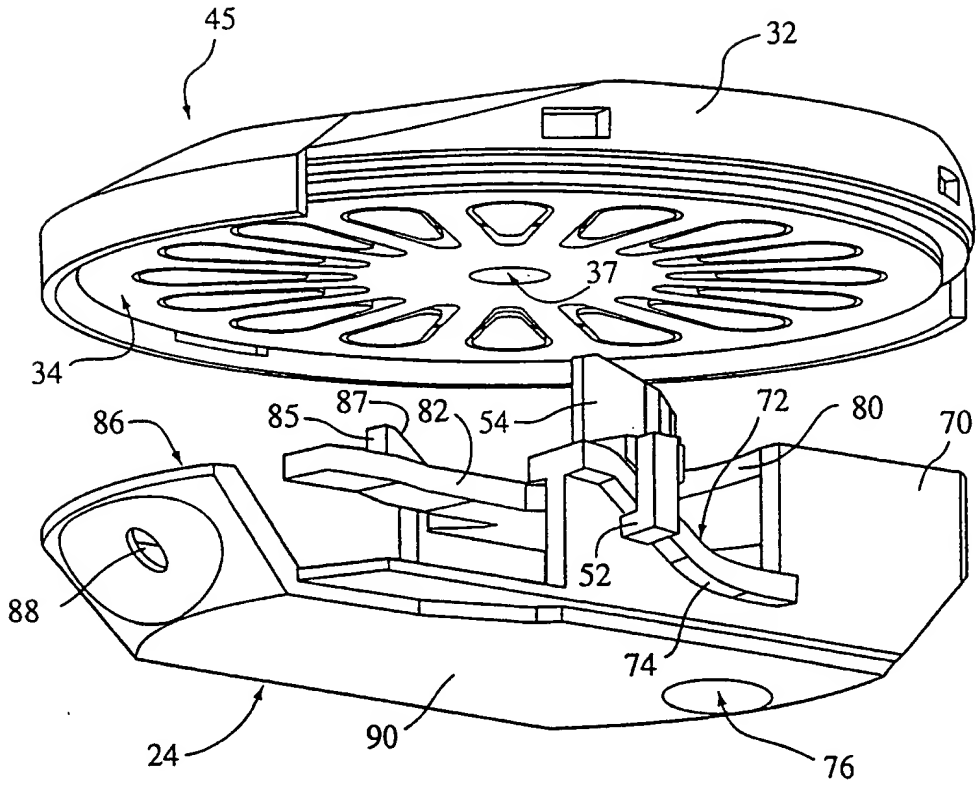

FIG. 4A

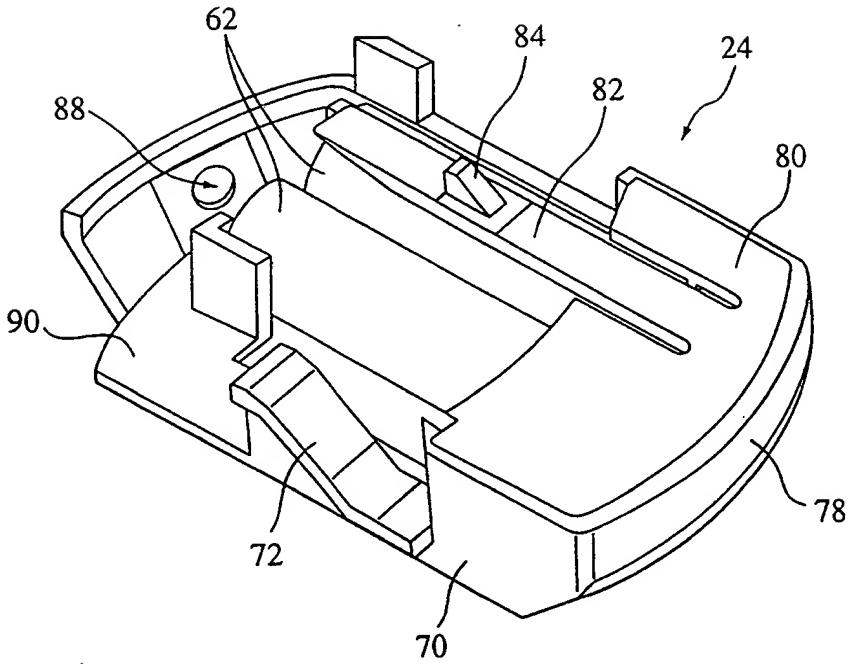

FIG. 4B

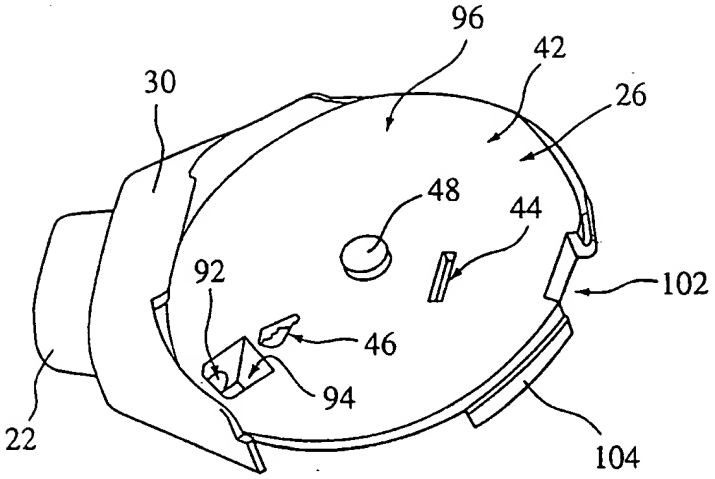

FIG. 5

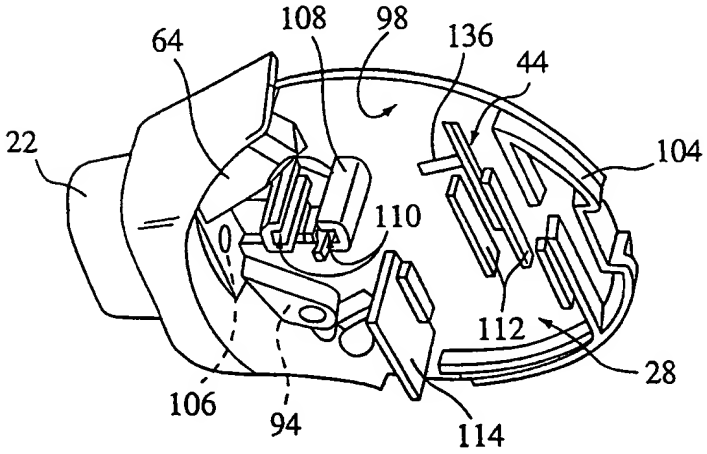

FIG. 6

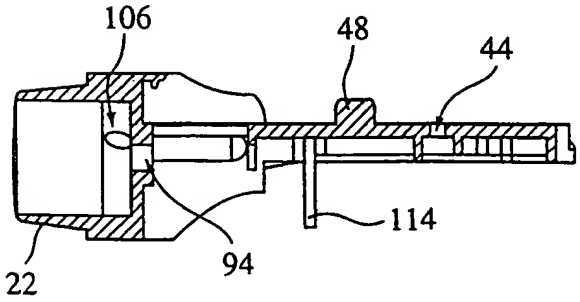

FIG. 7

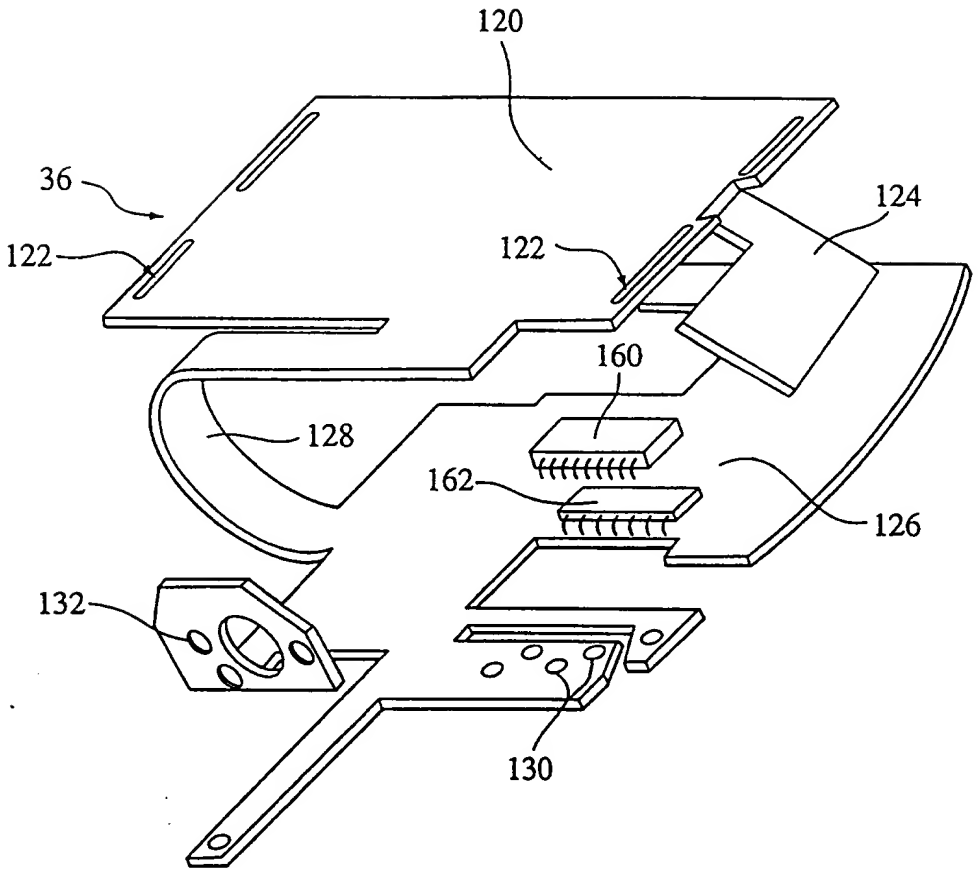

FIG. 8

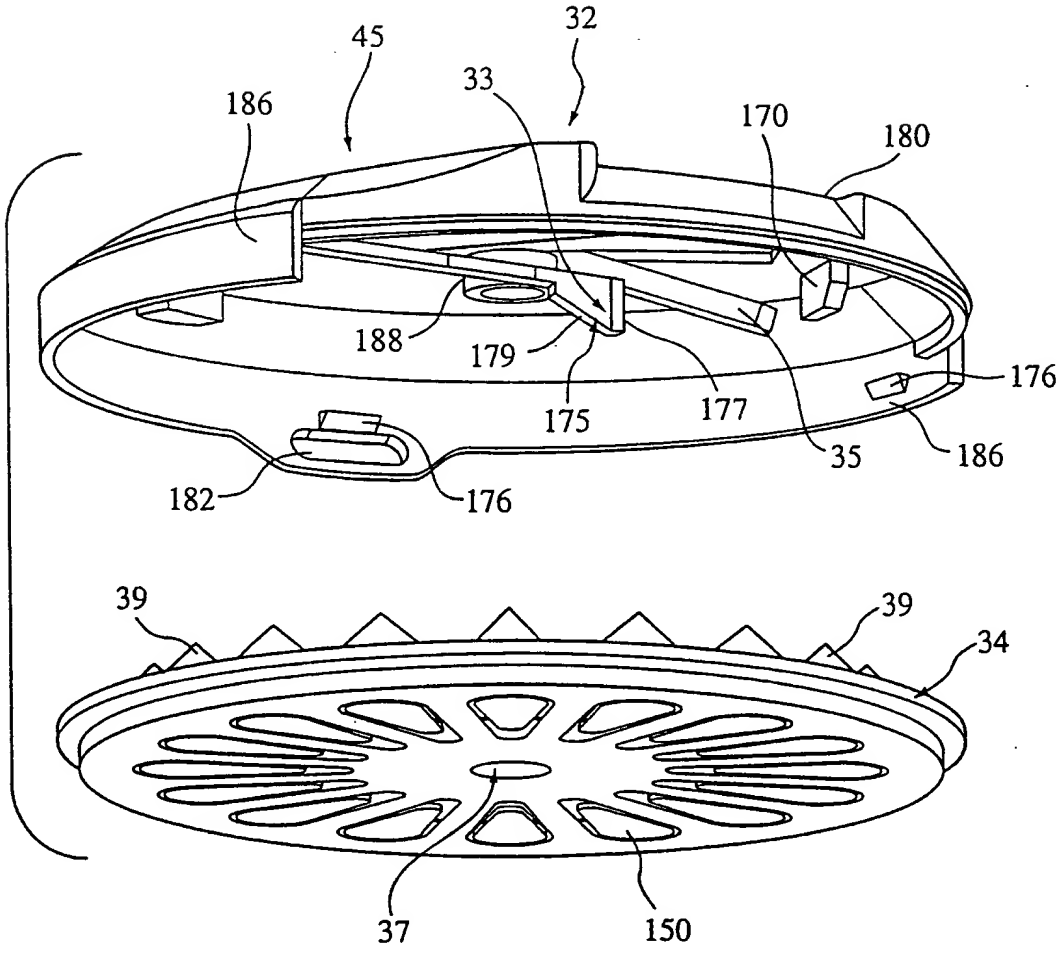
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FIG. 9

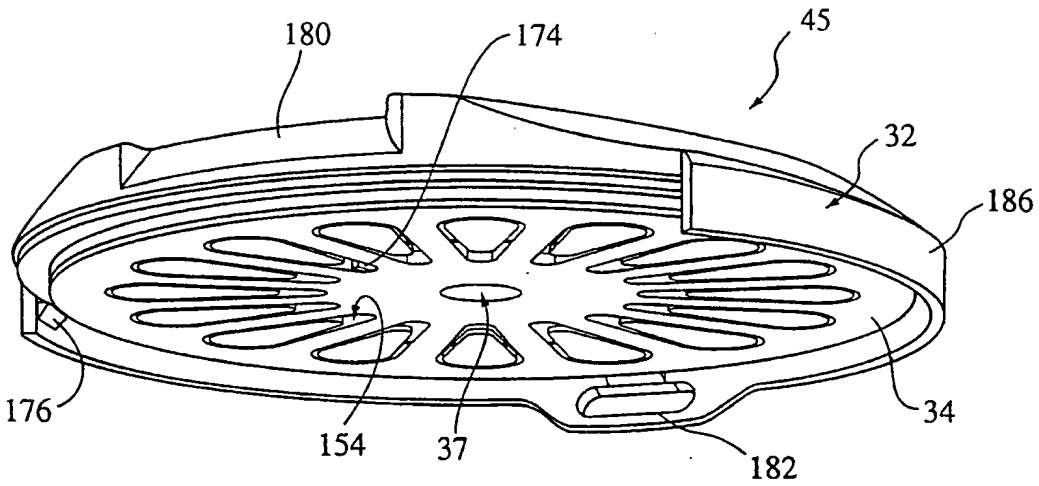

FIG. 10

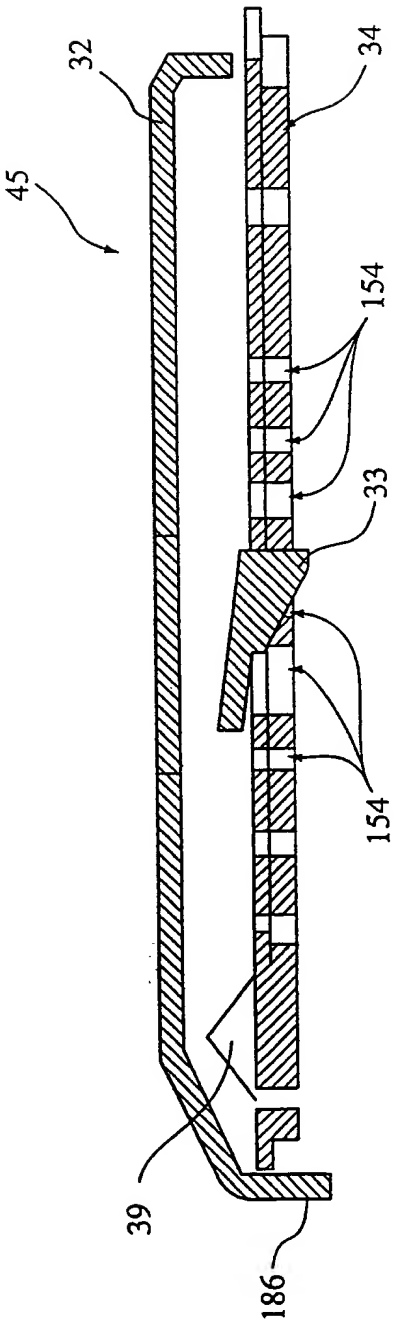
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FIG.11

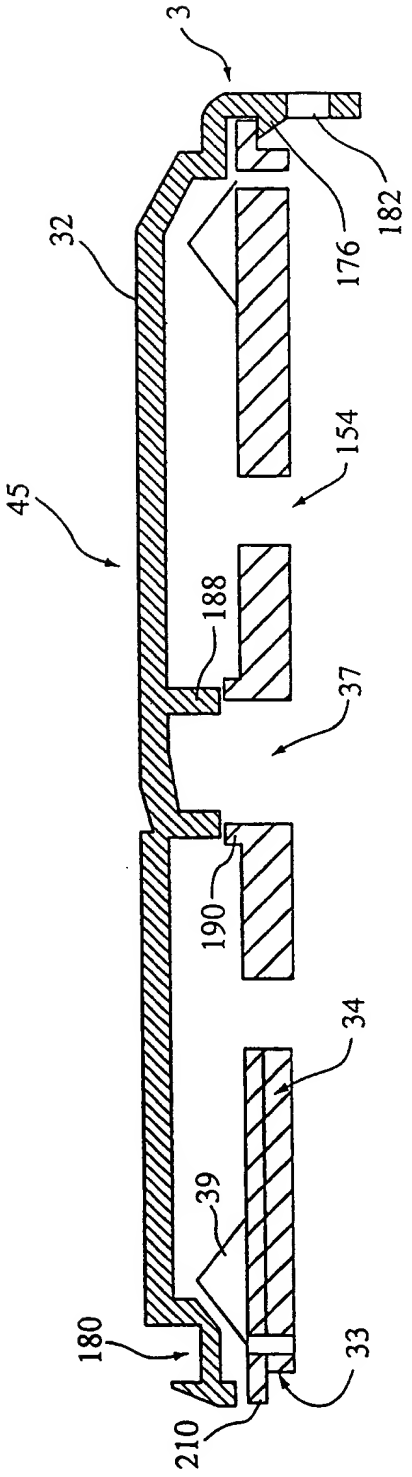
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FIG.12

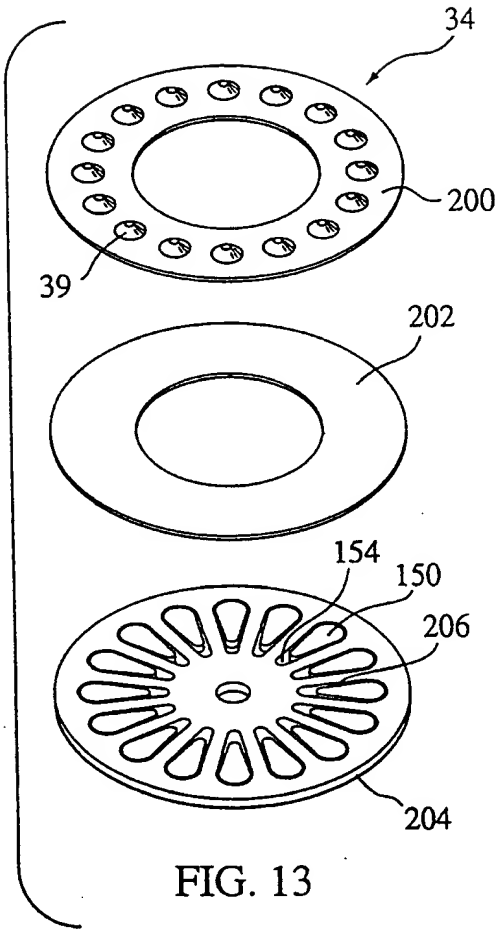

FIG. 13

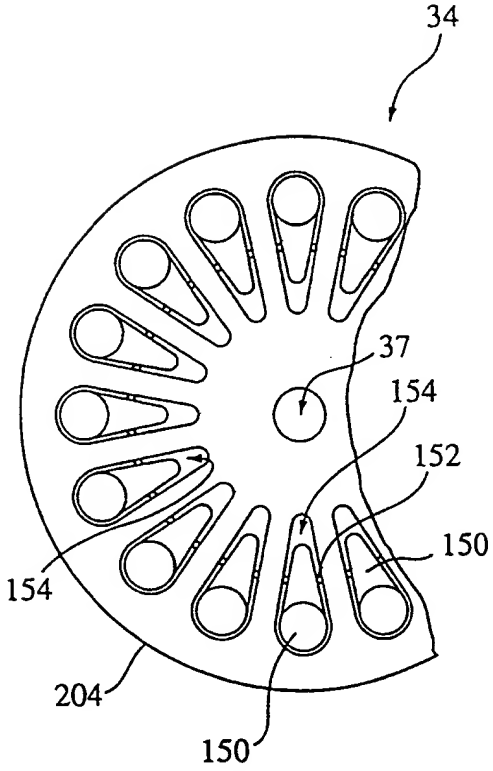

FIG. 14

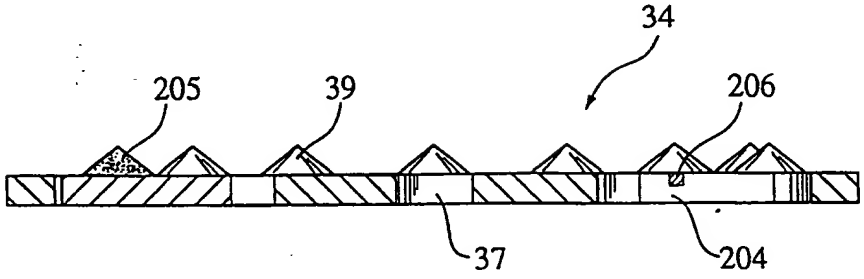

FIG. 15

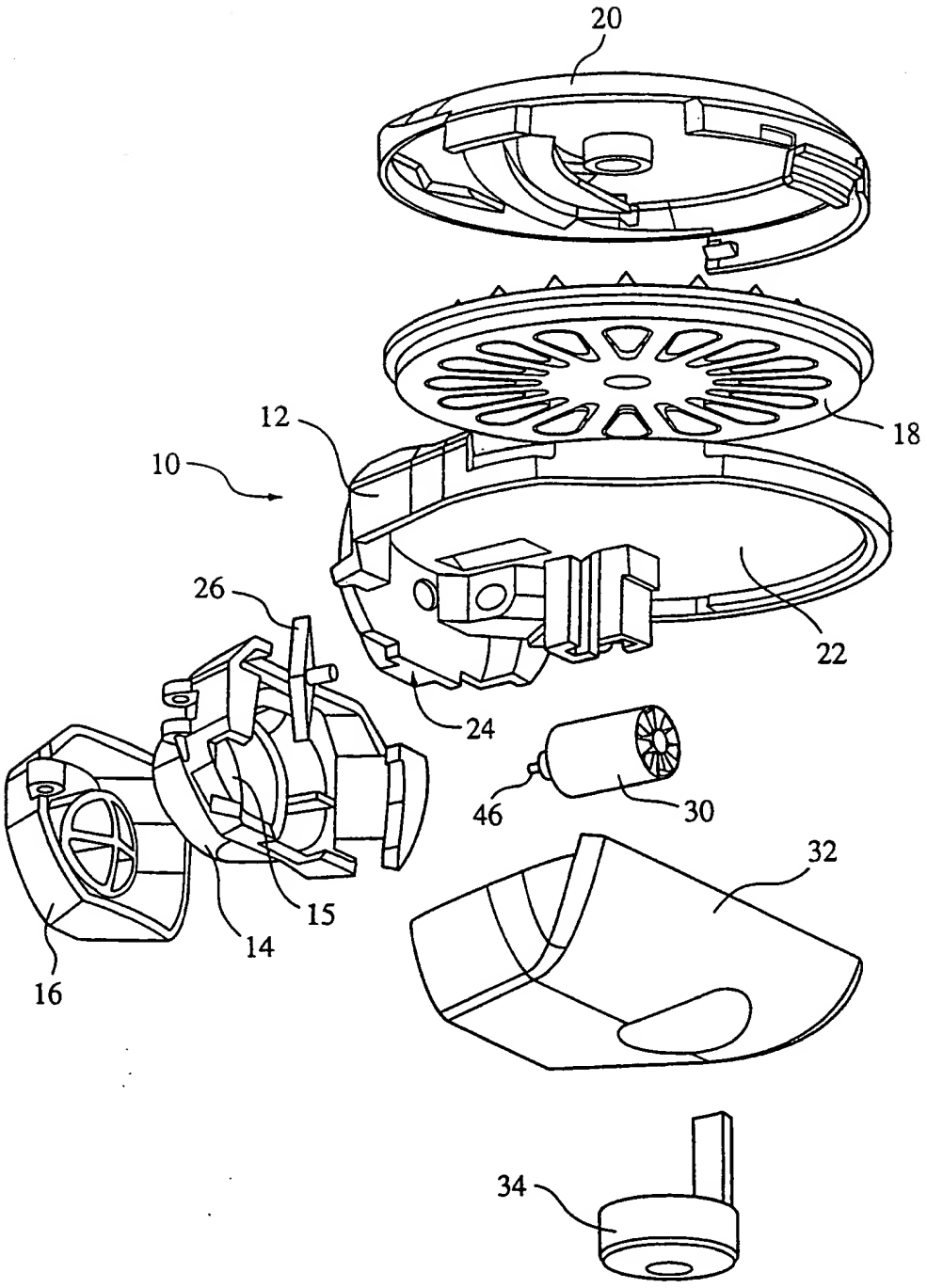

FIG. 16

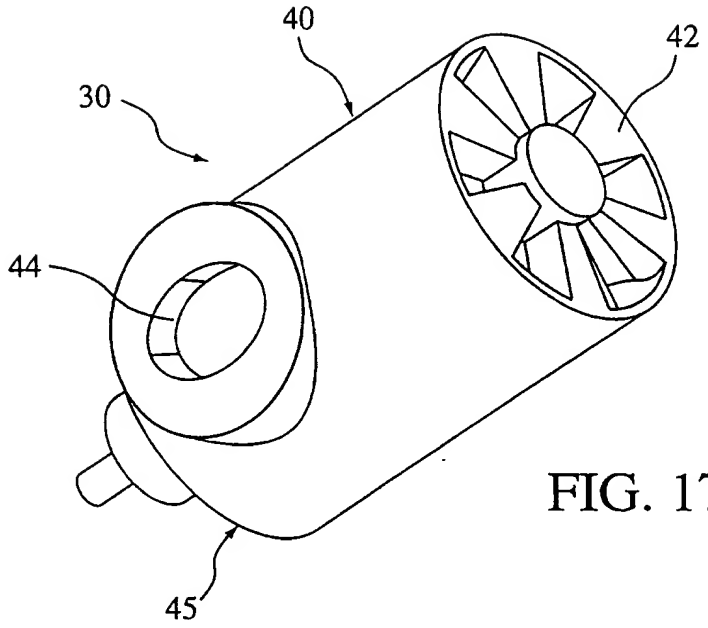

FIG. 17

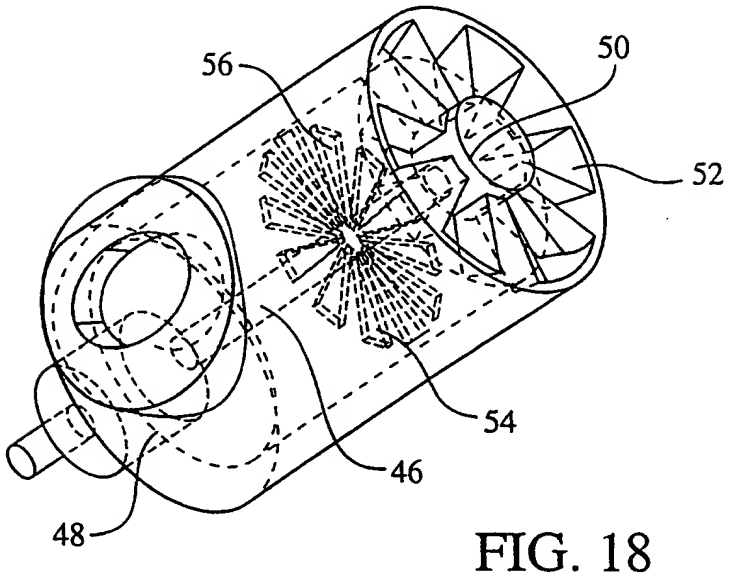

FIG. 18

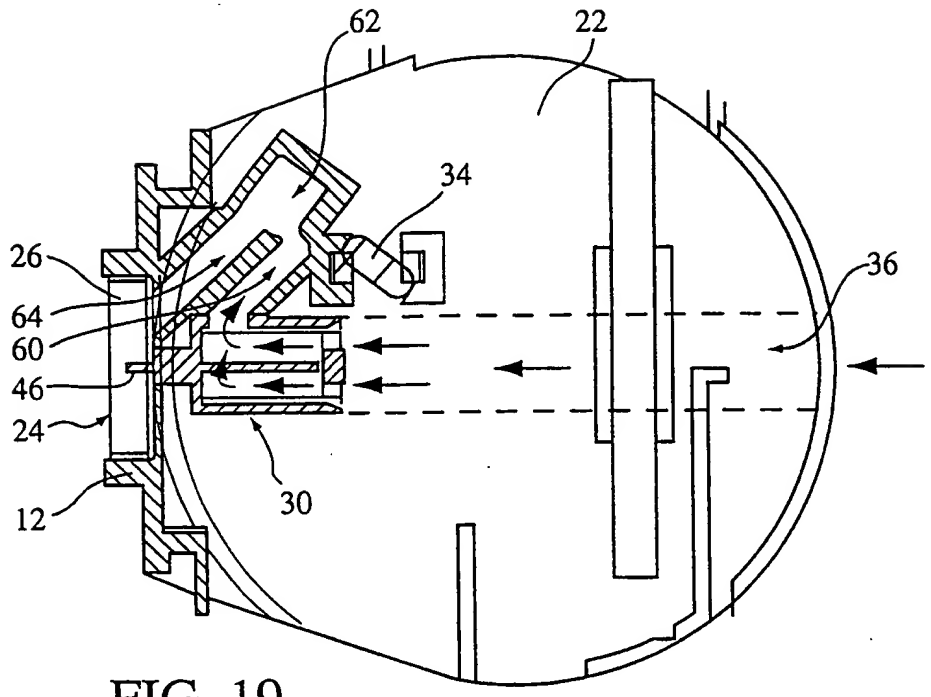

FIG. 19

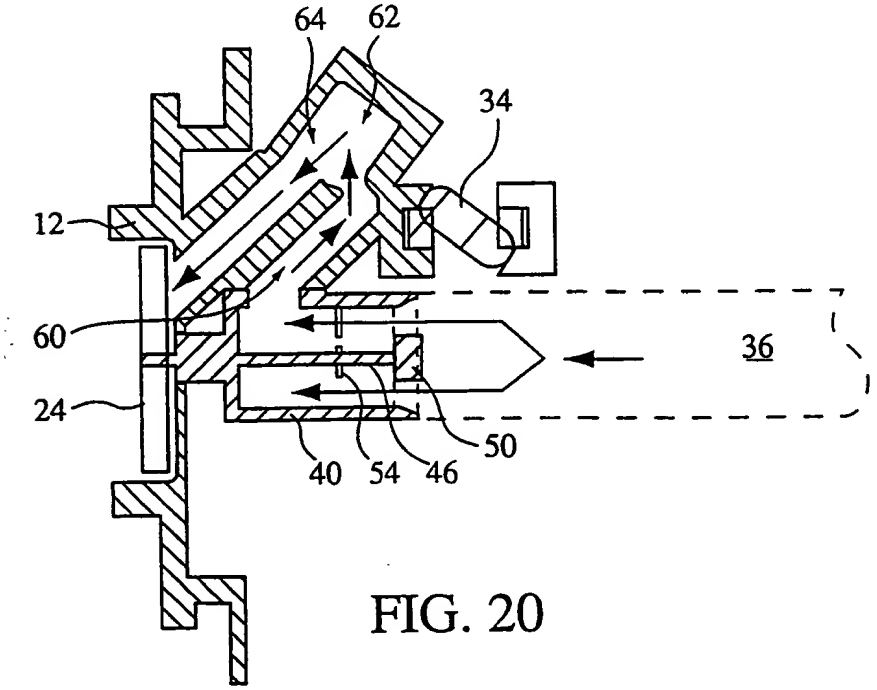

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/24914

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61M 15/00, 16/00; B05D 7/14; B65D 83/04, 06, 85/42
US CL :128/203.15, 203.21; 206/531, 532

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 128/200.14, 203.12, 203.15, 203.19, 203.21 203.23; 206/469, 531, 532, 538, 540

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
Search Terms: inhaler or inhalers, battery, housing, draw, ramp

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 4,811,731 A (NEWELL et al.) 14 March 1989, Figs 1-4 and 6, and col. 3, lines 34-65.	1, 5, 6, 20 --- 2-4
Y	US 5,327,883 A (WILLIAMS et al.) 12 July 1994, col. 5, lines 58-65, and col. 8, lines 29-36	2-4
X	US Des. 384,283 A (DAVIES et al.) 30 September 1997, and Figs. 1-5.	14-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

08 JANUARY 1999

Date of mailing of the international search report

02 FEB 1999

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